U.S. Patent Application Serial No. 09/881,836

Response dated June 14, 2004

Reply to OA of March 12, 2004

**AMENDMENTS TO THE CLAIMS:** 

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

Claim 1-4 (canceled).

Claim 5 (withdrawn): A process for growing doubly doped lithium niobate crystal as

claimed in anyone of Claims 1-4, wherein said process includes the following steps:

(1) Weigh up high purity Li<sub>2</sub>CO<sub>3</sub>, Nb<sub>2</sub>O<sub>5</sub>, Fe<sub>2</sub>O<sub>3</sub> and MgO, In<sub>2</sub>O<sub>3</sub> or ZnO powders according

to the crystal composition, and dry them at 120~150°C, then thoroughly mix them lasting for 24

hours, and keep them at 800~850°C for 2~5 hours to make Li<sub>2</sub>CO<sub>3</sub> decompose sufficiently, and then

sinter at 1050~1150°C for 2~8 hours to obtain doubly doped lithium noibate powder.

(2) Put the above doped lithium noibate powder into a Pt crucible after impacted, then heat

the powder by a middle frequency stove; Grow the doubly doped lithium niobate crystals using the

Czochralski pulling method along c or a axis via the procedures of necking, shouldering, uniform-

diametering, and tailing, with the pulling rate being 1~3 mm/h, the rotation rate being 15~30 rpm,

the temperature difference of the melt-crystal interface being 20°C, the temperature gradient in the

melt volume near the surface being 1.5 °C/mm, the temperature gradient above the melt surface being

1.0°C/mm, respectively.

(3) Pole and anneal the grown doped lithium noibate crystals at 1200°C to obtain single-

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(3) Pole and anneal the grown doped lithium noibate crystals at 1200°C to obtain single-domained doubly doped lithium niobate crystals.

## Claim 6 (canceled)

Claim 7 (currently amended): A doubly doped lithium niobate crystal, comprising:

$$\text{Li}_{1-x}\text{Nb}_{1+y}\text{O}_3$$
:  $\text{Fe}_m$ ,  $M_{qn}$ 

where, M is a member selected from the group consisting of Mg, Zn, and In, provided when M is Mg or Zn, q=2, and when M is In, q=3;

x is in the range of  $0.05 \le x \le 0.13$ ;

y is in the range of  $0.00 \le y \le 0.01$ ;

m is in the range of  $5.0 \times 10^{-5} \le m \le 7.5 \times 10^{-4}$ ; and

qn is in the range of  $0.02 \le qn \le \frac{0.03}{0.13}$ ,

wherein said doubly doped lithium niobate crystal has an average photorefractive response time from 3 to 5 seconds and a diffraction efficiency more than 68%.

Claim 8 (previously presented): The doubly doped lithium niobate crystal as claimed in claim 7, said

$$\text{Li}_{1-x}\text{Nb}_{1+y}\text{O}_3\text{:Fe}_{m},\, M_{qn}$$

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is doped with 0.007 to 0.03 wt% Fe, and M is 1.0 to 5.0 mol% Mg, where the congruent composition is [Li]/[Nb] = 0.90:0.95.

Claim 9 (previously presented): The doubly doped lithium niobate crystal as claimed in claim 7, said

$$\text{Li}_{1-x}\text{Nb}_{1+y}\text{O}_3$$
:  $\text{Fe}_{m}$ ,  $M_{qn}$ 

is doped with 0.01 to 0.05 wt% Fe, and M is 0.75 to 3.0 mol% In, where the congruent composition is [Li]/[Nb] = 0.91:0.95.

Claim 10 (previously presented): The doubly doped lithium niobate crystal as claimed in claim 7, said

$$Li_{1-x}Nb_{1+y}O_3$$
:  $Fe_m$ ,  $M_{an}$ 

is doped with 0.02 to 0.06 wt% Fe, and M is 1.5 to 6.5 mol% Zn, where the congruent composition is [Li]/[Nb] = 0.87:0.95.

Claim 11 (currently amended): A three-dimensional optical storage material, comprising the doubly doped lithium niobate crystals as claimed in any one of claims 7-10, 12 or 13 7-9 or 10.

Claim 12 (new): A doubly doped lithium niobate crystal, comprising:

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$$\label{eq:Li_1-x} Li_{1-x}Nb_{1+y}O_3: Fe_m, \ In_{qn}$$
 where q=3; 
$$x \ \text{is in the range of } 0.05 \le x \le 0.13;$$
 
$$y \ \text{is in the range of } 0.00 \le y \le 0.01;$$
 
$$m \ \text{is in the range of } 5.0 \ x \ 10^{-5} \le m \le 7.5 \ x \ 10^{-4}; \ \text{and}$$
 
$$qn \ \text{is in the range of } 0.02 \le qn \ 0.13, \ \text{and}$$

said doubly doped lithium niobate crystal is doped with 0.01 to 0.05 wt% Fe, and In is 0.75 to 3.0 mol% In, where the congruent composition is [Li]/[Nb] = 0.91:0.95.

Claim 13 (new): A doubly doped lithium niobate crystal, comprising:

$$\label{eq:Li_1-x} Li_{1-x}Nb_{1+y}O_3: Fe_m,\ Zn_{qn}$$
 where q=2; 
$$x \ \text{is in the range of } 0.05 \le x \le 0.13;$$
 
$$y \ \text{is in the range of } 0.00 \le y \le 0.01;$$
 
$$m \ \text{is in the range of } 5.0 \ x \ 10^{-5} \le m \le 7.5 \ x \ 10^{-4}; \ \text{and}$$
 
$$qn \ \text{is in the range of } 0.02 \le qn \ 0.13, \ \text{and}$$

said doubly doped lithium niobate crystal is doped with 0.02 to 0.06 wt% Fe, and Zn is 1.5 to 6.5 mol% Zn, where the congruent composition is [Li]/[Nb] = 0.87:0.95.